ALGAL TUFT STRUCTURES IN STROMATOLITES FROM THE UPPER TRIASSIC OF SOUTH-WEST ENGLAND

by M. J. MAYALL *and* V. P. WRIGHT

ABSTRACT. Stromatolites in the Upper Triassic (Rhaetic) of south-west Britain contain lineations within (algal) laminae which are compared to filament tufts in modern algal mats. These Triassic tuft structures were formed by the clumping of highly motile micro-organisms displaying strong phototaxis, probably oscillatoriacean cyanophytes. Although such structures are common in modern algal mats they have not previously been recognized in ancient stromatolites. Their preservation in the Triassic is due to early lithification. Such fossil structures provide information on the nature of the algal community even though no actual algal remains are preserved.

DESPITE a large and detailed literature on modern stromatolite-building communities, the poor preservation of most ancient stromatolites is such that little can be deciphered about their original communities. Silicified stromatolite biotas are an exception and some skeletal stromatolites can also yield information on the type of community which built them.

The Landscape (Cotham) Marble is a thin stromatolitic limestone occurring in the uppermost Triassic (Rhaetic) of south-west Britain. It was shown to be of algal origin by Hamilton (1961), although its over-all form is a function of the complex interactions of the algal community, colonization by a problematic tubiform microfossil *Microtubus communis* (Flugel 1964), bioturbation, sedimentation, and other environmental factors (Wright and Mayall, 1981). The stromatolite occurs at the top of the Cotham Member of the Upper Rhaetic which was deposited in a shallow, probably schizohaline lagoon. It is overlain by the Langport Member which is composed of micrites and peloidal limestones with a restricted bivalve fauna.

This paper describes some unusual structures in the algal laminites of the Landscape Marble and in laterally equivalent stromatolites elsewhere in the Rhaetic of south-west Britain.

DESCRIPTION OF TUFT STRUCTURES

In sections of the Landscape Marble cut normal to bedding the algal laminites contain dark subvertical to vertical lineations, between 3 and 7 mm long and under 0·5 mm wide (Pl. 95, fig. 1). They occur either in flat laminated horizons or in small domes or ridges. The algal laminations are strongly inflexed near the lineations (Pl. 95, fig. 2). In plan view the lineations form irregular discontinuous horizontal lineations which occasionally outline polygons up to a few centimetres across. Occasionally some of the most highly inclined laminae occur in cone-shaped structures or in the form of steep-sided ridges a few centimetres long. The cone-shaped structures resemble the stromatolite form genus *Conophyton* Maslov, (emend. Komar, Raaben and Semikhatov).

In thin section the algal laminites are composed of fenestral micrites. The fenestrae are now in-filled by sparry calcite (text-fig. 1) and are most commonly fine vertical or inclined tubular fenestrae from 50 to 200 μm wide and up to 700 μm long, but irregular fenestrae up to 450 μm in diameter also occur. The longer tubular fenestrae are bent towards the lineations which are formed by the coalescence of the fenestrae walls (text-fig. 1).

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TEXT-FIG. 1. Detail of structure. Light areas are calcite filled voids. Photograph from thin section X7. Specimen from Huish Colliery Quarry (ST 696543, see Savage 1977). (University of Reading, Dept. of Geology, Archive No. S26675).

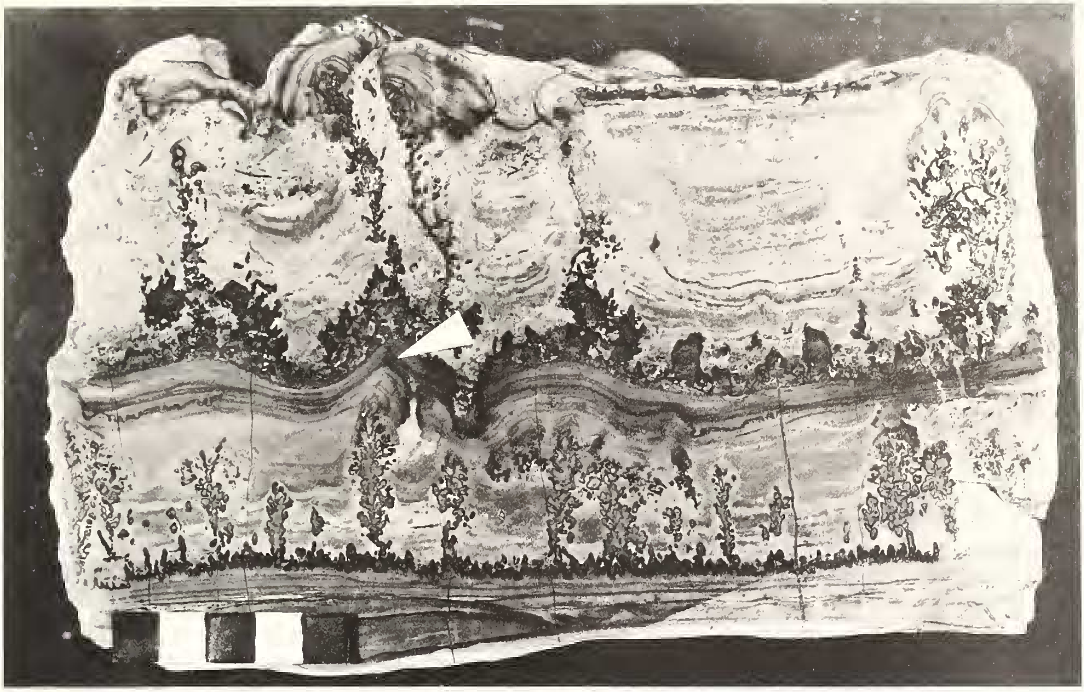
Interpretation

The tubular fenestrae are comparable to algal filament mould fabrics found in modern algal sediments (Monty 1976). They form by the oxidation of algal filaments leaving voids (fenestrae) in the algally bound or precipitated material around the filaments. The lineations and inflexed laminae seem to have been formed by the local coalescence of algal filaments, and are analogous to tuft or pinnacle structures described from modern algal mats (see Gebelein 1974, pl. 1B). Such structures are common and have been called pinnacle mats (Kinsman and Park 1976; Krumbein and Cohen 1977) or tufted mats (Logan, Hoffman and Gebelein 1974; Walter, Bauld and Brock 1976; Horodyski 1977). The formation of these tufts in modern algal mats involves two processes; firstly clumping of the algal filaments must occur to bring many filaments together into a single mass, and secondly, the profile of this mass must be extended into a tuft by the filaments moving upwards over one another. The

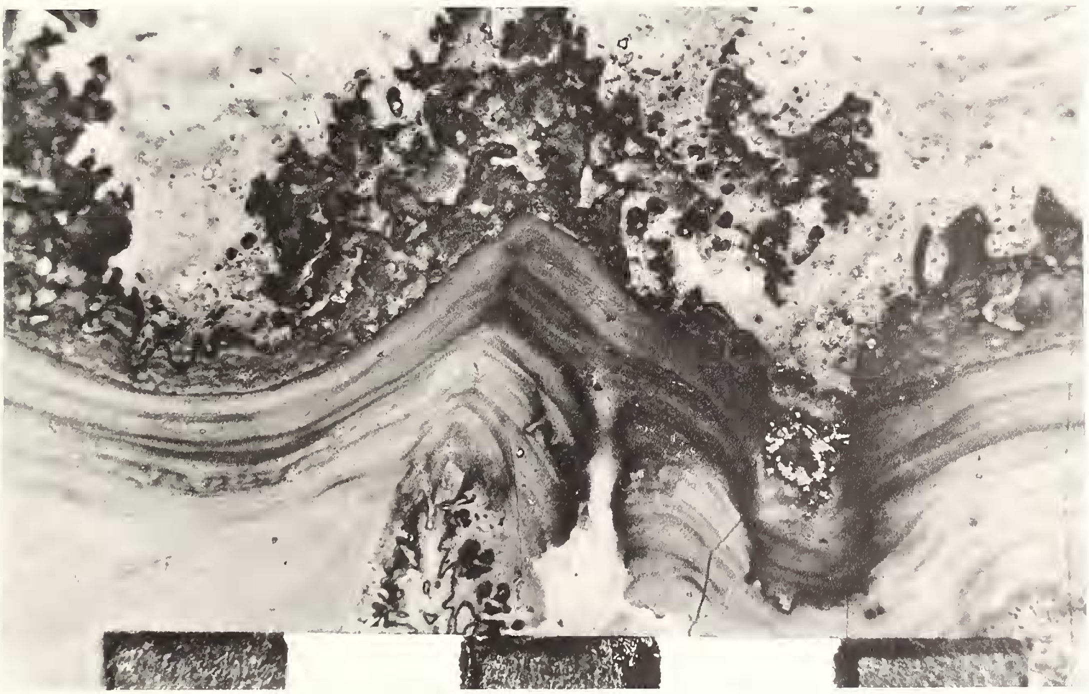
EXPLANATION OF PLATE 95

Fig. 1. Vertical section through the Cotham Marble. Axial lineation arrowed. Each scale division is 1 cm. Specimen from Wickwar near Chipping Sodbury (see Whittard and Smith 1944). (University of Reading, Dept. of Geology, Archive No. S26674).

Fig. 2. Detail of lineation arrowed from specimen above.

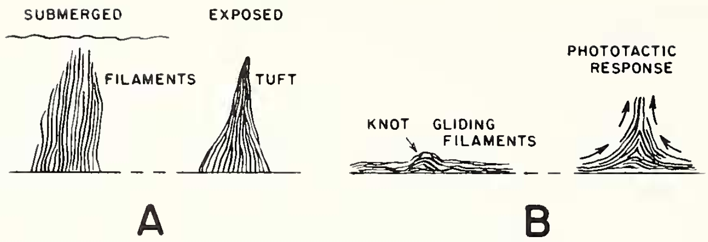


1



2

MAYALL and WRIGHT, stromatolite structure



TEXT-FIG. 2. Mechanisms of tuft formation. A. Tufts caused by exposure of filaments (after Horodyski 1977, fig. 3J). B. Tufts formed by filaments gliding upwards over a knot (after Walter *et al.* 1976, fig. 36.3).

clumping, that is the coalescing, of the filaments can be caused (text-fig. 2) either by the exposure bringing mucilage-coated filaments into contact with one another (text-fig. 2A; Golubic 1976, p. 120; Horodyski 1977, fig. 3J) or by the gliding of algal filaments resulting in the formation of knots over which other filaments are deflected upwards because of phototaxis (text-fig. 2B; Walter *et al.* 1976, fig. 36.3). The curving of the filament mould fenestrae in the Triassic structures suggests that the filaments did not collapse inwards but were drawn towards the developing tuft as in the second case discussed above.

Tuft structures in modern algal mats commonly develop into small single ridges which may outline polygons (Logan *et al.* 1974; Walter *et al.* 1976; Horodyski 1977). They are strikingly similar to the plan views of the Triassic lineations. Walter *et al.* (1976) attributed the development of the ridges to the deflection of algal filaments on to filament knots in a preferred direction. Polygonal structures can of course form in other ways and are a very common feature in algal mats. The most common process forming polygons is desiccation. However, the polygonal structures in these Triassic stromatolites are not associated with typical desiccation features such as prism cracks. Park (1973, p. 116) and Gunatilaka (1975, p. 284) have described ridge-like features developed in algal mats which they interpret as the result of expansive growth of the mat. These authors do not describe the formation of these ridges in detail but the close association of tuft fabrics and the ridges in the stromatolites described herein strongly suggests that filament clumping was the main cause of ridge growth.

DISCUSSION

Tuft structures have not been described from ancient stromatolites. In modern algal mats they are generally heavily distorted during early shallow burial by compaction and dehydration (Park 1977, p. 499; Horodyski, Bloeser and Vonder Haar 1977, p. 687) and such structures have only a low to moderate preservation potential (cf. Park 1977). They are unlikely to survive even the earliest phases of burial and diagenesis unless either calcified or silicified (e.g. see Walter *et al.* 1976). The occurrence of the cementing bivalve *Atreta intusstriatus* on some of the stromatolites suggests that the algal mats underwent early lithification.

The structures described have formed as a result of filament clumping by motile filamentous algae. Various micro-organisms including cyanophytes display gliding motility (Castenholz 1973, p. 327) and is well-developed in the families Oscillatoriaceae and Nostocaceae (Fritsch 1945). In the modern examples of tufted mats cited above oscillatoriacean cyanophytes are the dominant element in the mats. Usually it is species with large trichomes and thick sheaths which form the tufts (Gebelein 1974, p. 580) since they provide the rigidity needed to support their vertically orientated filaments, e.g. *Lyngbya aestuarii* in Shark Bay, Western Australia (Logan *et al.* 1974), in the Persian Gulf (Kinsman and Park 1976), and in the Laguna Mormona, Mexico (Horodyski 1977). Additionally *Phormidium* forms quite large structures in Yellowstone Park (Walter *et al.* 1976). However, tufted mats can also be formed by some small, thin-sheathed oscillatoriaceans as pointed out by Awramik (1977, p. 119), e.g. *Schizothrix* in the Persian Gulf and Shark Bay (Golubic 1976, figs. 1 and 2).

It therefore seems likely that the tufted structures in the stromatolites described herein were built by oscillatoriacean cyanophytes. What remains uncertain is whether the ancient mats were only composed of motile oscillatoriaceans. Modern algal mats are often complex in composition and are frequently vertically stratified with different species occurring at different levels within the mat (e.g. Golubic 1973, p. 458; Walter, Golubic and Preiss 1973). The vertical superposition of these various layers, as the mats accrete, leads to the obliteration of any fine microstructures, as a result of the disruption of earlier microstructure by the later algal layers. The relatively simple microfabric seen in these Triassic mats might suggest that little overprinting occurred and that perhaps the mats were compositionally quite simple.

CONCLUSIONS

Algal tuft structures are preserved in the Upper Triassic Landscape (Cotham) Marble and laterally equivalent stromatolitic limestones in south-western Britain. These tuft structures and associated polygonal ridges provide evidence of the behaviour of the algal community which built the stromatolites despite the absence of any actual algal remains. The tufts were built by highly motile, filamentous micro-organisms displaying phototaxis, probably oscillatoriacean cyanophytes. Although tuft structures are very common in modern algal mats they have not been described from ancient stromatolites because such structures are easily destroyed during the earliest stages of diagenesis. The preservation of these structures in the Triassic is the result of early lithification. Other ancient stromatolites, lacking preserved organic remains, may also contain structures diagnostic of particular algal communities.

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